JPR 1860.2A

JSC Radiological Health Manual

SA/Space Life Sciences

September 12, 2005

Verify that this is the correct version before use.

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

JSC Radiological Health Manual

JPR 1860.2A

Approved by

_____(Original signed, 9/12/2005)_____
Jeffrey R. Davis, M.D.
Director, Space Life Sciences

CHANGE RECORD

Revision	Date	Originator/Phone	Description
Basic Edition	March 1989	Space Life Sciences	To define policy and procedures.
Revision A	August 2005	SD/Mary Van Baalen, ext. 39998	Update Document to remove advisory language and convert to “requirements.”

FOREWORD

This Manual is issued to provide instructions to personnel, both NASA and contractor, in the procurement and safe handling of radioactive materials or radiation-producing equipment while being used or stored at the Johnson Space Center (JSC). Suggestions for changes and improvements to this Manual should be submitted to the JSC Radiation Safety Committee for consideration via the Radiation Safety Officer (RSO), Space Life Sciences Directorate.

TABLE OF CONTENTS

PART 1 - GENERAL DESCRIPTION

1.1 PURPOSE

This Manual describes the policy, organization, procedures, and requirements for the radiological health and safety activity of the Johnson Space Center (JSC).

1.2 SCOPE

This Manual includes organization, training, and responsibilities for radiological health and safety at JSC. It defines JSC procedures and requirements for procurements, use, handling, storage, shipment, and disposal of sources of ionizing radiation, as well as personnel monitoring an emergency procedure. It also indicates reference documents from which more detailed information may be obtained when necessary.

1.3 JSC POLICY

Pursuant to JSC Policy Directive 1860.4, it is JSC policy to: (1) exercise centralized control over operations involving use of radioactive materials and radiation-producing equipment; (2) assure that exposure of personnel to ionizing radiation from radioactive materials or radiation-producing equipment is kept as low as is reasonably achievable; (3) assure that compliance with applicable federal, state, and local regulations is maintained; and, (4) hold each supervisor responsible for training those employees who are to use ionizing radiation and to see that all work is in compliance with applicable regulations.

1.4 APPLICABILITY

The procedures, requirements, and radiation protection practices as set forth in this Manual apply to all organizational elements of JSC and to all contractors working in facilities under the administrative control of JSC. It shall be noted that regulations quoted are Federal Statutes imposed on NASA under terms of its licenses with the Nuclear Regulatory Commission, (NRC), and applicable regulations promulgated by Occupational Health and Safety Administration (OSHA), Food and Drug Administration (FDA), and the Department of Transportation (DOT). Questions concerning details of current regulations or the applicability of regulations should be referred to Space Medicine and Health Care Systems Office.

1.5 REVISION OF MANUAL

Approved revisions to this Manual shall be developed by and for approval of the JSC Radiation Safety Committee. Specific changes shall be numbered and transmitted by the Space Medicine and Health Care Systems Office, and will consist of a change checklist, and the new pages to be inserted into the document.

PART 2 – JSC ORGANIZATION FOR RADIOLOGICAL HEALTH

2.0 JSC ORGANIZATION FOR RADIOLOGICAL HEALTH

The Director of Space and Life Sciences, with authority granted by the JSC Director, has appointed the Radiation Safety Committee and the Medical Isotopes Operations Subcommittee to assure control of radiation and to assure compliance with federal regulations governing the use of ionizing radiation. Policies of the Radiation Safety Committee are carried out in day-to-day activities by an authorized radiation user. A RSO has been designated in a contractor team of professional health physicists, which assists the radiation user by providing administrative and technical instructions in radiological health.

The Radiation Constraints Panel established by the JSC Director is responsible for coordinating all operational aspects of radiation pertaining to manned space flights managed by JSC.

The overall organization chart for Radiation Safety at JSC is outlined in Figure 1 of this part.

2.1 RADIATION SAFETY COMMITTEE

The Radiation Safety Committee implements the functions and responsibilities as outlined by its Policy Charter.

a. Coordinates and controls the use of ionizing radiation.

b. Reviews and approves all JSC radiological health policies and procedural requirements.

c. Develops and coordinates materials incorporated in the JSC Radiological Health Manual, including all revisions, thereof.

d. Performs the functions defined by Title 10, Code of Federal Regulations, Part 33.

2.2 MEDICAL ISOTOPES OPERATIONS SUBCOMMITTEE

The Medical Isotopes Operations Subcommittee performs the functions and assumes the responsibilities outlined below.

a. Reviews the training and experience in medical uses of radioactive material of physicians wishing to use radiopharmaceuticals and approves those physicians who are to use or directly supervise the human use of radioactive materials.

b. Reviews, from the standpoint of radiological health and safety, and approves or disapproves requests for use of radioactive materials or radiation-producing equipment in or on humans.

c. Evaluates and coordinates the use of isotopes for medical purposes under a private practice or organizational license in or for JSC programs.

2.3 RADIATION SAFETY OFFICER (RSO)

The RSO is responsible to the Space Life Sciences Directorate and is a member of the Radiation Safety Committee and the Medical Isotopes Subcommittee. The duties and responsibilities of the RSO are as outlined below:

a. Assumes control and initiates corrective action in radiological emergencies.

b. Coordinates with the NRC on matters concerning the regulatory and reporting functions through the Space Medicine and Health Care Systems Office.

c. Prepares incident and overexposure reports required by the NRC and other agencies.

d. Performs technical reviews of all proposed uses of facilities for radioactive material and radiation machines to assure conformity with applicable regulations, standards and good practice.

e. Assists line supervisors as primary contact on a day-to-day basis for matters related to radiation safety.

f. Assures that the disposal of radioactive waste is safe and complies with Federal, state, local government and JSC requirements.

g. Operates the Health Physics Laboratory and the Isotope Storage Facility.

h. Provides training and indoctrination of personnel in radiation safety.

i. Reviews and approves all purchase requests for radiation sources and irradiation services for compatibility with licensing requirements.

j. Performs radiation protection surveys and radiation safety evaluations including leak tests required by NRC license.

k. Provides radiation instrument calibration services and controls the instrument calibration facility.

l. Provides personnel dosimetry for ground operations. Interprets and reports results and maintains permanent dosimetry records.

m. Performs radio-assays as required.

n. Maintains a central inventory of all radiation sources and provides a repository for those that are not in use.

o. Inspects and maintains records of all receipts and shipments of radiation sources.

p. In the case of unsafe practices, the RSO shall stop the use of radioactive materials immediately. The RSO shall allow resumption of the work upon the resolution of the unsafe condition, or the matter shall be referred to the Radiation Safety Committee for reconsideration of the authorization.

2.4 RADIATION CONSTRAINTS PANEL

The Radiation Constraints Panel is responsible for coordinating all operational aspects of radiation pertaining to manned space flights managed by JSC. The panel shall perform the following specific functions:

a. Review all operational aspects of radiation including coordination of exposure limits, mission objectives, crew and operational considerations and program requirements to arrive at a consolidated Center position.

b. Coordinate and evaluate all requirements for all operational radiation instrumentation, and recommend appropriate action to the cognizant program.

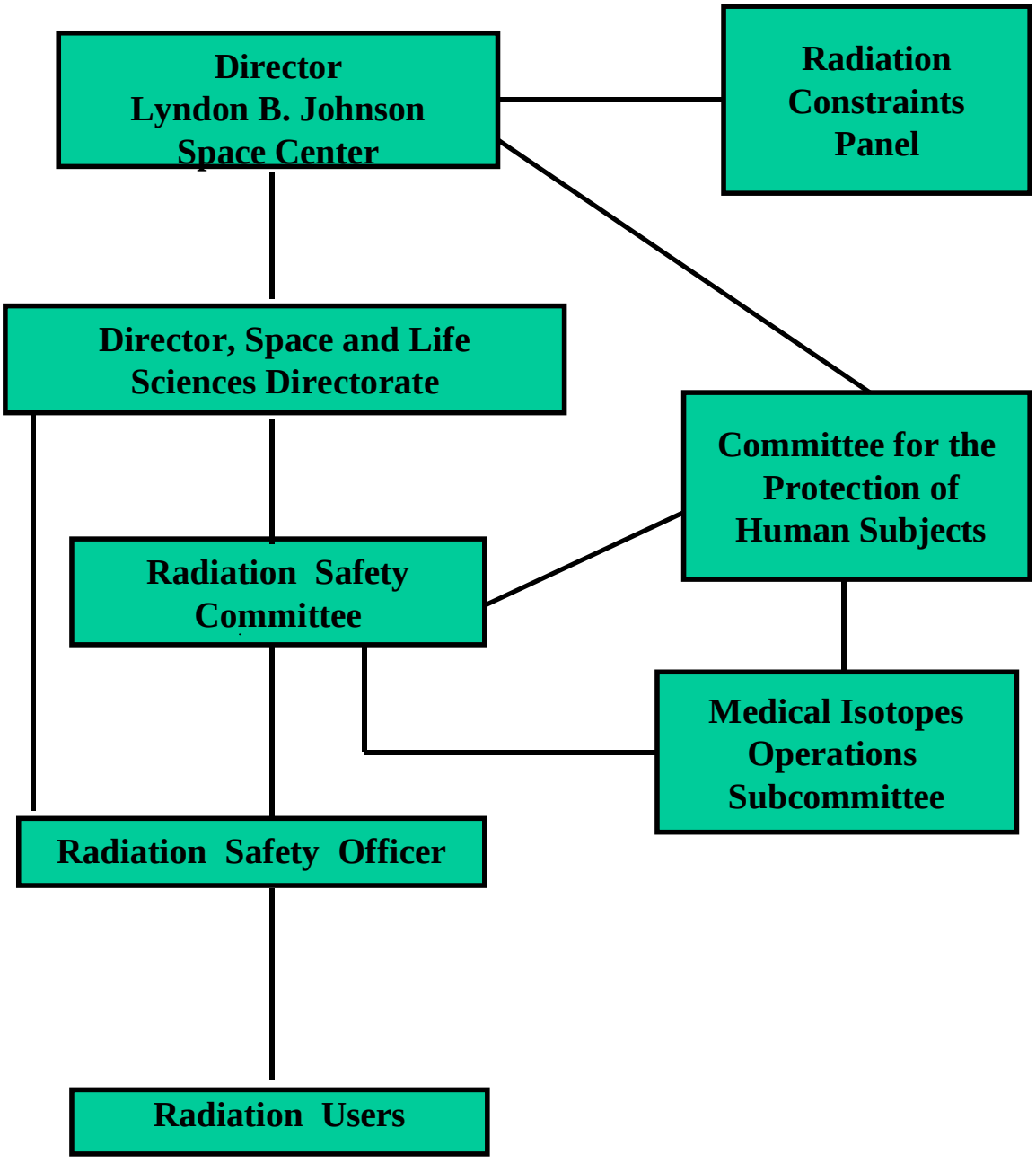
c. Review all missions for radiation constraints, nominal exposure, trade-offs, contingencies, procedural requirements, mission rules, and other mission considerations.

d. Review all radiation support for each mission, including onboard instrumentation, the Mission Control Center, radiation network, other Government agencies, and additional support appropriate to the mission.

e. Collect, review, and publish for each mission a detailed listing of all radiation sources on the vehicles being flown.

The Radiation Constraints Panel establishes a Center position on operational impacts of radiation on human space flights in the areas of acceptable ionizing and electromagnetic radiation exposure limits; mission objectives, mission rules, and crew procedures; program requirements (technical content, funding, and schedules); and requirements for operational radiation measurements. Review plans for each mission to identify and assess the impact of operational radiation constraints, expected nominal ionizing radiation exposure, operational procedures and mission rules, and contingency plans to reduce exposures to as low as reasonably achievable.

Figure 1 - Line of Responsibility and Authority for the JSC Radiation Protection Program.



PART 3 – ROUTINE PROCEDURES AND REQUIREMENTS

3.0 ROUTINE PROCEDURES AND REQUIREMENTS

3.1 USER

The user or operator of any ionizing radiation source shall have adequate training and experience to receive, use, and have custody of specific regulated sources of ionizing radiation, as determined by the Radiation Safety Committee.

Authorized radiation users or operators shall be responsible for insuring compliance with the provisions of this Manual.

3.2 RADIATION USE AUTHORIZATIONS

a. In order for the Radiation Safety Committee to evaluate potential hazards associated with the use of a regulated radiation source, a Radioactive Material Use Authorization (JSC Form 1942) or Radiation Machine Use Authorization (JSC Form 1943) shall be submitted by the proposed user of the radiation source through his management. The requested use authorization shall contain a description of the operating procedures, which include detailed safety precautions, the use locations, emergency procedures, identifies the qualifications of proposed users (via JSC From 1944) and their NASA supervisor or technical monitor. Prior to, or concurrent with the preparation of the radiation use request, the radiological health staff shall perform a radiological safety analysis, or initial radiation protection survey, and a report of these findings shall be submitted to the Radiation Safety Committee, along with the radiation use request.

b. The Radiation Safety Committee shall review the originator's proposal, the user's qualifications and recommendations made by the RSO. If satisfied that the proper precautions are to be taken, they shall approve the request, binding the users to all statements represented. If additional recommendations are considered appropriate by the Committee, a written condition shall be added to the authorization applicable to each recommendation.

c. Modifications to approved authorizations shall be submitted on the JSC Form 1942 or Form 1943 and follow the same processing as the original request. In addition, information presented by the originator, for consideration by the Committee, previous survey results and hazard evaluations shall be given primary importance for approval of renewed or modified use authorizations. Information contained in previous submittals to the JSC Radiation Safety Committee shall be incorporated by reference provided references are clear and specific.

3.2.1 SPECIAL REQUIREMENTS FOR OFF-SITE RADIATION USE AUTHORIZATION

Prior to approving a Radiation Use Authorization for an organizational element of JSC in which the material or equipment shall be used at a temporary-job-site (a facility not under the administrative control of JSC) the following requirements shall be satisfied:

a. Written authorization shall be obtained from the administration of the facility where use of radioactive materials is proposed. If the facility or institution holds a By-Product License from the NRC or an Agreement State, the use of by-product materials shall be concurred on by the local RSO and/or the Radiation Safety Committee.

b. To assure minimal radiation exposure to individuals and confirm no residual radioactive contamination remains in the facility, an individual shall be named with adequate training and experience in radiological health activities to select suitable instrumentation and perform monitoring tasks as determined necessary by the JSC Radiation Safety Committee.

c. Procedures and arrangements for disposal of radioactive waste generated at the temporary job site shall be formally specified and approved by the JSC Radiation Safety Committee. The preferred waste disposal method shall be by direct transfer to a NRC or Agreement State licensee, authorized to perform collection and/or disposal or radioactive waste.

d. Duration of radiation use under these procedures shall be limited to 30 days inclusive. When a demonstrated need for a longer use period exists, the request for Radiation Use Authorization shall be submitted at least 60 days in advance of needed date to allow time for the JSC Radiation Safety Committee to secure the necessary approval from the NRC.

All records of radiation surveys, personnel monitoring and radioactive material transfers shall be maintained by the use supervisor and submitted to the RSO, at the completion of the authorized use. Any incidents involving individuals overexposed, lost sources or contamination problems shall be reported immediately to the RSO at JSC, in accordance with Part 4 of this Manual.

3.2.2 INTERIM APPROVALS

The Radiation Safety Committee has established a policy, within the NRC license application, for timely response between meetings to requests for use. Small changes to approved uses or new uses that involve low risk can be provisionally approved by the written concurrence of the Chairman of the Radiation Safety Committee, the RSO and the Radiation Health Officer (RHO).

Only with approval of all three of these officials is the use authorized and then only until the next scheduled meeting of the Radiation Safety Committee at which time it is reviewed by the full committee.

3.3 RADIATION SURVEYS

a. Initial Radiation Surveys - Prior to the use of radioactive material or the operation of radiation-producing machines, an initial radiation survey shall be performed by the radiological health staff. Based on this survey, general procedures for safe handling and use will be recommended while leaving as much latitude as is safe and feasible.

b. Periodic Radiation Surveys - The radiological health staff shall schedule periodic inspections and radiation surveys of each facility where radiation is being used. Any unsafe practices shall be called to the attention of the RSO who may revoke the Radiation Use Authorization with concurrence from the RHO. Revocation of Use Authorization shall require immediate notification of available members of the Radiation Safety Committee and appropriate NASA management.

c. Contamination Control -To minimize radioactive contamination in work areas, the users of liquid or powdered radioactive materials shall conduct area wipe tests designed to detect contaminated surfaces. These contamination tests shall be conducted on a frequency governed by the amount of radioactive material in use. Records of these tests shall be maintained for inspection by the users.

The results of initial radiation surveys and periodic radiation surveys shall be presented to the JSC Radiation Safety Committee to allow a complete review and evaluation of existing and proposed uses of ionizing radiation.

d. Survey Instruments - The RSO shall provide assistance in the selection of applicable instrumentation for periodic monitoring by the approved area users. Short term loaning of protective equipment and survey meters shall be handled through the Radiation Safety Office.

3.4 TRAINING AND EDUCATION

Instruction of personnel is of great importance to the success of radiation protection activity. As a minimum and prior to working with ionizing radiation, individuals shall have had either radiation experience and/or training covering at least the following points:

a. General description of radiation and its hazards.

b. Basic principles of radiation safety.

c. Radiation safety procedures relevant to duties associated with employment.

d. JSC policies and appropriate Federal regulations.

e. Emergency procedures.

Periodic instructions shall be carried out on-the-job by the RSO. Emphasis shall be placed on updating operating methods and emergency procedures.

If, due to the nature of work to be done, personnel are subject to unusual hazards, they shall be required to have additional training as determined by the Radiation Safety Committee.

3.5 CONTROL OF PROCUREMENT AND TRANSFER OF RADIOACTIVE MATERIAL TO JSC

For each request for procurement or transfer of radioactive material to the JSC license, the following procedure is used:

a. Prior to purchase or transfer of radioactive material to JSC, the Radiation Safety Committee shall have reviewed and approved the proposed use of the radioactive material.

b. The RSO, or his alternate, shall approve and sign each purchase request or request for transfer of radioactive material to the JSC license.

c. No amounts exceeding the licensed amounts shall be procured or transferred to JSC without explicit approval of the NRC.

d. Instructions on every purchase order for radioactive material shall require that the notice "**Notify the Radiation Safety Officer Upon Arrival"** be placed on the address label.

e. JSC Receiving is instructed to notify the RSO when it receives any radioactive shipment and release the shipment only to the RSO.

f. Any radioactive material arriving at JSC without prior authorization by the RSO shall be held by the RSO until appropriate disposition can be determined.

3.6 AREA DESIGNATIONS

The following area designations shall apply for purposes of radiation control at JSC:

a. Airborne Radioactivity Area - A room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations:

(1) In excess of the derived air concentrations (DACs) specified in appendix B, to 10 CFR Parts 20.1001 - 20.2401, or

(2) To such a degree that an individual present in the area without respiratory protective equipment could not exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

b. Annual Limit on Intake (ALI) - The derived limit of the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent to 5 rems or a committed dose equivalent of 50 rems to any individual organ or tissue.

c. Contamination Area - Any area, accessible to personnel, from which 220 disintegrations per minute (dpm) of alpha particles or 2200 dpm of beta particles of gamma photons may be removed from a 100 centimeter square area.

d. Controlled Area - An area outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

e. Derived Air Concentration (DAC) - The concentration of a given radionuclide in air, which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI.

f. High Radiation Area - Any area accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive, in any one hour, a dose in excess of 100 millirem.

g. Radiation Area - Any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of 2 millirem.

3.7 RADIATION DOSE LIMITS

Radiation dose limits at JSC are based upon limits specified by the NRC in 10 CFR 20. It shall be recognized that the JSC limits are established as maximum values and, in all cases, personnel exposure shall be maintained as far below the limits specified in this part as practical. A particular effort shall be made to keep the radiation exposure of an embryo or fetus the very lowest practicable level during the entire gestation period as recommended by the National Council on Radiation Protection and Measurements.

a. Occupational Dose Limits for Adults

(1) An annual limit, which is the more limiting of:

(a) The total effective dose equivalent being equal to 5 rems (0.05 Sv);

(b) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv).

(2) The annual limits to the lens of the eye, to the skin, and to the extremities, which are:

(a) An eye dose equivalent of 15 rems (0.15 Sv), and

(b) A shallow-dose equivalent of 50 rems (0.50 Sv) to the skin or to any extremity.

(b) Occupational Dose Limits for Minors

The annual occupational dose limits for minors are 10 percent of the annual dose limits specified for adult workers in 10 CFR Part 20.1201.

(c) Dose to an Embryo/Fetus

The licensee shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem.

(d) Dose Limits for Individuals Members of the Public

(1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem in a year, exclusive of the dose contribution from the licensee's disposal of radioactive material into sanitary sewerage in accordance with 10 CFR Part 20.2003.

(2) The dose in any unrestricted area from external sources does not exceed 0.002 rem in a one hour.

3.8 AIRBORNE CONCENTRATION LIMITS

Maximum airborne concentrations of radioactive materials to which personnel at JSC shall be exposed are also based upon limits specified by the NRC in 10 CFR Part 20. Again, the JSC limits are established as maximum values, and in all cases airborne concentrations shall be maintained at the lowest practical level.

(a) Airborne Radioactivity Area - A room, enclosure, or area in which airborne radioactivity materials, composed wholly or partly of licensed material, exist in concentrations:

(1) In excess of the DACs specified in Appendix B, to 10 CRF Parts 20.1001 - 20.2401.

(2) To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the ALI or 12 DAC hours.

3.9 PERSONNEL MONITORING

(a) Personnel monitoring is required in any area where there is a probability that an individual may receive a radiation dose in excess of 10 percent of the limits in Part 3 Section 3.7 of this Manual.

(b) The details of the monitoring procedure shall be determined in each case by the RSO in consultation with the Radiation Use Supervisor and with consideration of the dose limits. (See Part 3 Section 3.7 of this Manual.)

(c) Personnel monitoring procedures shall include as a minimum the wearing of personnel Whole Body or Extremity Ring Dosimeters and/or pocket dosimeters. Film badges shall be changed for processing on or about the first working day of each month. The personnel dosimetry devices shall be exchanged for processing on a bi-monthly basis. Personnel monitoring devices shall be available from the RSO. When needed, the appropriate radio-assay service shall be furnished.

(d) The RSO shall maintain a permanent record of all personnel dosimetry reports. If a report indicates an overexposure, an investigation shall be initiated to determine the cause and to suggest remedial action. The overexposure shall be reported to the NRC in compliance with 10 CFR 19.

(e) Individuals determined to require radiation monitoring shall be advised annually of the worker's exposure to radiation of radioactive material as shown in records maintained by JSC Radiation Safety Office.

3.10 POSTING AND LABELING

The posting and labeling requirements for JSC are based on the regulations in 10 CFR 19 and 10 CFR 20. The radiation symbols prescribed by this section shall be the conventional magenta or purple three-bladed design on a yellow background. Any additional information that may minimize exposure to radiation or to radioactive material shall be on or near signs and labels posting and labeling requirements are as follows:

(a) Radiation Area - Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION RADIATION AREA

(b) High Radiation Area - Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION HIGH RADIATION AREA

All high radiation areas established for a period of 31 days or more shall be equipped with a control device which shall cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirem in one hour upon entry into the area or shall energize a conspicuous, visible or audible alarm signal in such a manner that the individual entering and the supervisor of the operation are made aware of the entry.

(a) Airborne Radioactivity Area - Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION AIRBORNE RADIOACTIVITY AREA

(b) Storage Area - In addition to the above, each area in which radioactive material is used or stored and which contains any radioactive material, other than natural uranium or thorium, in an amount exceeding 10 times the quantity of such material specified in Appendix C of 10 CFR 20, or which contains natural uranium or thorium in an amount exceeding 100-times the quantity specified in Appendix C of 10 CFR 20 shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION RADIOACTIVE MATERIAL(S)

(e) Operating Procedures and General Information - Areas in which individuals are employed in activities covered by the JSC Radiological Health Manual shall be posted with the following

in such a manner to be readily observable to individuals on their way to or from their place of employment, or kept in a suitable place so that they are available for examination upon request:

(1) A current copy of 10 CFR 19.

(2) A current copy of 10 CFR 20.

(3) A current copy of 29 CFR 1910.96.

(4) A copy of the NRC license and document references therein.

(5) A copy of JPR 1860.2A, JSC Radiological Health Manual.

(6) Notice of cited violations of appropriate Federal regulations and the resulting materials.

In addition to the above, Form NRC-3, "Notice to Employees," shall be posted in such a manner to be readily observable in areas utilizing radioactive materials.

(f) Containers

(1) Each container of radioactive material shall bear a durable, clearly visible label identifying the radioactive contents as to radionuclide, quantity, and the date of assay.

(2) The label shall bear the radiation symbol and the words:

CAUTION RADIOACTIVE MATERIAL(S)

(g) Radiation-producing Machines or Equipment - X-ray machines, X-ray diffraction units, electron microscopes, and other similar equipment shall bear a durable, clearly visible label bearing the radiation caution symbol and the words:

CAUTION
THIS MACHINE PRODUCES X-RADIATION WHEN ENERGIZED

(h) Exemptions to Posting and Labeling Requirements - Exemptions to posting and labeling requirements at JSC shall be approved by the RSO and shall be limited to the following:

(1) An area is not required to be posted with a sign because of the presence of a sealed source provided the radiation level is twelve inches from the three (3) – ten (10) surface of the source container or housing does not exceed five (5) millirem per hour.

(2) Areas containing radioactive materials for less than eight hours do not require signs provided the materials are constantly attended during such periods by an individual who shall take precautions necessary to prevent a radiation exposure to any individual in excess of JSC limits.

(3) Areas are not required to be posted with signs because of the presence of radioactive material packaged and labeled in accordance with applicable transportation regulations.

(4) Containers that do not contain materials in quantities greater than amounts specified in Appendix C of 10 CFR 20.

(5) Containers containing only natural uranium or thorium in quantities no greater than ten (10) times amounts specified in Appendix C of 10 CFR 20.

(6) Containers that do not contain licensed materials in concentrations greater than ten (10) times the quantity specified in Appendix B, Table 3, of 10 CFR 20.

(7) Containers when they are attended by an individual who shall take precautions necessary to prevent the radiation exposure to any individual in excess of the limits of 10 CFR 20.

(8) Containers, which are accessible only to individuals authorized to use them, or to work in the vicinity, provided the contents are identified to such individuals by a readily available written record.

(9) Containers when they are in transport and packaged and labeled in accordance with applicable transportation regulations.

3.11 LEAK TEST

(a) Each sealed source containing by-product material, other than Hydrogen 3 and radiation sources and devices exempted from leak testing as provided by 10 CFR Parts 30 and 31, with a half-life greater than thirty days and in any form other than gas shall be tested for leakage and/or contamination at intervals not to exceed six (6) months. In the absence of a certificate from a transferor indicating that a test has been made within six (6) months prior to the transfer, the sealed source shall not be put into use until tested.

(b) Notwithstanding, the periodic leak test required by the preceding paragraph, any licensed sealed source containing by-product material emitting beta or gamma with an activity of 100 microcuries or less, sources of alpha or neutron emitting radioactive material with an activity of 10 microcuries or less, shall be exempt from periodic leak testing.

(c) The periodic leak test required by this condition does not apply to sealed sources that are stored and not being used. The sources accepted from this test shall be tested for leakage prior to any use or transfer to another person unless they have been leak tested within six (6) months prior to the date of use or transfer.

(d) The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. The test sample shall be taken from the sealed source or from the surfaces of the device in which the sealed source is permanently mounted or stored on which one might expect contamination to accumulate. Records of leak tests results shall be kept in units of microcuries and maintained for inspection by the NRC.

(e) If the test reveals the presence of 0.005 microcurie or more of removable contamination, the RSO shall immediately withdraw the sealed source from use and shall cause it to be decontaminated and repaired or to be disposed of in accordance with NRC regulations. A report shall be filed within (5) five days of the test with the office that is charged with By-Product Material Licensing, U.S. Nuclear Regulatory Commission, Washington, DC 20555, describing the equipment involved, the test results, and the corrective action taken. A copy of such report shall also be sent to the Director, Region IV, Office of Inspection and Enforcement, Nuclear Regulatory Commission, 611 Ryan Plaza Drive, Suite 1000, Arlington, Texas 76012.

(f) Tests for leakage and/or contamination shall be performed by the radiological health staff as authorized by the NRC to perform such services.

3.12 INSTRUMENT CALIBRATION

All radiation detection instruments shall be calibrated and records maintained by the RSO.

(a) Portable Survey Meters - Portable instruments shall be calibrated prior to issue, while in use, and/or after any repair.

The calibration procedure requires exposure to known radiation fields with at least two points in each range checked. Generally, the calibration checks shall be made in the regions of 10-30 percent and 70-90 percent of full scale. In the event it is not possible to obtain a calibration check for a particular range, the instrument shall be considered uncalibrated for that range and shall also be marked. Should all calibration check readings fall within ten percent, no change shall be made in instrument response to exceed the above tolerance, a calibration adjustment shall be made according to the manufacturer's specific procedures. If the instrument's response exceeds twenty percent either because of rate or energy dependence and cannot be corrected by adjustment, suitable correction factor graphs or charts shall be prepared and attached to the instrument.

(b) Laboratory Counting Equipment - All radiation counting equipment shall be calibrated prior to use and shall be accomplished by use of comparison standards.

3.13 RADIOACTIVE WASTE DISPOSAL

Special waste receptacles shall be provided by the RSO for the disposal of low level solid and liquid radioactive wastes. These receptacles shall be conspicuously marked with the radiation symbol and the words:

CAUTION RADIOACTIVE MATERIALS

Separate receptacles shall be provided for low level solid and liquid wastes, and these wastes shall be strictly segregated. Concentrated stock solutions of radioactive materials, sealed sources and

other high level materials shall not be disposed of in low level waste containers. The radiological health staff, upon request by the Radiation Use Supervisor, shall be responsible for disposal or removal and storage of such high level material.

The contents of the radioactive waste receptacles shall be collected by the radiological health staff periodically. The arrangements for ultimate disposal of all radioactive waste resulting from JSC operations shall be the responsibility of the Occupational Health Office Contractor. Disposal of high level material is limited to an appropriate licensee of the NRC or one of its Agreement States who will conduct final disposal operations.

Records of all radioactive waste disposals shall be maintained by the RSO.

3.14 LAUNCH OF RADIOACTIVE MATERIAL

Authorization of Launch - By-product material shall be used in launched spacecraft when authorized by NASA Headquarters, which assumes responsibility for coordination with other agencies to assure compatibility of the proposed use with national policies and objectives.

PART 4 - EMERGENCY PROCEDURES

4.1 GENERAL

Contamination is easily spread during an emergency situation such as a fire, explosion, accidental breakage of a container, or spilling. Radioactive materials can be spread very rapidly and easily by the air currents set up by a fire. They may also find their way into an air-conditioning system, or, if spilled on the floor, they may be tracked around by personnel. This contamination is undetectable except by the use of special radiation-detecting devices. Since it is extremely difficult to set up adequate detection controls in an emergency, preplanned emergency procedures are included in this Manual. Personnel whose work involves the use of radioactive materials shall familiarize themselves with these procedural requirements.

4.2 PROCEDURES AFTER SPILLAGE OF RADIOACTIVE MATERIAL

(a) General Responsibilities - Immediately after the occurrence of a spill that cannot be controlled by the people involved, an evacuation order shall be issued by the Radiation Use Supervisor in charge. The Radiation Use Supervisor shall then notify by telephone, or by the most rapid method of communication, the RSO, and follow his instructions or those of his authorized representative.

(b) Specific Precautions - Unless he has received different instructions from the RSO, the person involved in the spillage shall proceed to:

(1) Prevent all non-emergency personnel from approaching the contaminated area, or from attempting to deal with the spillage.

(2) Close all windows and other openings such as ventilating grills.

(3) Close and lock all doors.

(4) If the spillage involves powdered or gaseous radioactive material, seal all doors, and other openings after closing. Suitable sealing materials usually handy are wide masking tape, adhesive tape, or heavy wrapping paper, clipped or pasted to the frames.

(c) Rules Affecting Conduct of All Personnel

(1) No person shall enter the contaminated area until the radiological health staff has conducted a survey and has pronounced the area safe to resume work or below a defined contamination area as defined in Part 3.6(f) of this Manual.

(2) Unauthorized personnel shall not attempt to make a survey, or to clean up the spillage.

(3) Decontamination procedures shall **ALWAYS** be conducted under the supervision of the RSO or of his authorized qualified delegate.

(4) Personnel shall be instructed to keep their movements in the contaminated area to a minimum, to avoid spreading the contaminant by tracking.

4.3 FIRE IN RADIATION AREAS

In case of fire in areas where radioactive materials are in use, every practical effort shall be made by the user to replace the material in its shielded container. If this is not possible, it is the responsibility of the user to promptly notify the Fire Department and Radiation Safety Officer or his alternate.

Fire Department personnel should be knowledgeable of radiation hazards, and the Fire Department is encouraged to contact the RSO for periodic instruction. The Fire Department shall be kept notified in writing of all locations of radioactive materials in amounts that may prove hazardous to Fire Department personnel either externally or internally or that may present a serious contamination problem. Upon call to one of these locations, the Fire Chief, in consultation with the RSO, shall be responsible to see that proper procedures are implemented to minimize radiation exposure to personnel and spread of contamination.

4.4 LOST OR MISPLACED SOURCES OF RADIATION

Lost or misplaced sources of radiation should be reported immediately to the RSO.

The RSO shall immediately prepare all reports required after a theft or loss of licensed material. The Radiation Safety Committee Chairman or Space Life Sciences Director shall coordinate and transfer such reports to the NRC.

4.5 NOTIFICATION OF ACCIDENTS

A Radiation Use Supervisor will report to the RSO immediately any incident or accident involving radiation sources or malfunction of radiation producing equipment. The RSO will promptly investigate any such report and advise NASA management of his findings.

APPENDIX A - GLOSSARY

JSC Radiological Health Manual

accelerator	A machine that accelerates electrically charges particles to high velocities. Types of accelerators include the cyclotron, linear accelerator and Van de Graaff generator.
agreement state	Any state with which the Nuclear Regulatory Commission has entered into an effective agreement to perform specific parts of the Atomic Energy Act of 1954.
alpha radiation	Positively charged particles, each identical to a helium nucleus and emitted from a nucleus during radioactive decay.
alpha emitter	Any nuclide that emits alpha radiation.
becquerels (Bq)	One Bq=1 disintegration per second (S^{-1}).
beta radiation	High speed electrons each emitted from a nucleus during radioactive decay.
beta emitter	Any nuclide that emits beta radiation.
bremsstrahlung	Electromagnetic radiation emitted by charged particles when they are slowed down by electric fields in passage through matter.
by-product material	Any radioactive material (excluding source and fissionable material) obtained in the process of producing or using source or fissionable material; includes fission products produced in the nuclear reactors.
contamination	The presence of radioactive material (radioactive) anywhere it is not desired.
curie	The unit of radioactivity; equals 37 billion nuclear decays per second.
decay	Spontaneous disintegration of the nucleus of an unstable atom by the emission of charged particles and/or electromagnetic radiation.
decontamination	The removal of radioactive contaminants.
dose	The quantity of energy imparted to a mass of material exposed to radiation.
dose rate	The radiation dose delivered per unit time.
dosimeter	Any device that detects and measures (radiation) radiation dose.

film badge	A packet of photographic film used for measurement of radiation dose for personnel monitoring purposes.
fission	The splitting of a heavy nucleus into roughly equal parts, accompanied by the release of energy and frequently one or more neutrons.
fissionable material	Any material readily fissioned by slow neutrons.
gamma radiation	Highly penetrating electromagnetic radiation of nuclear origin.
gray (Gy)	The SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 Joule/kilogram (100 rads).
half life	The time in which half the atoms in a radioactive substance decay.
health physics	A profession devoted to the protection of man and his environment from unwarranted radiation exposure.
ionization chamber	An instrument that detects and measures ionizing radiation by observing the electric current created when radiation ionizes gas in the chamber.
ionizing radiation	Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.
isotope	Atoms with same atomic number but different atomic weights.
licensed material	Any material received, possessed, used or transferred under a general or special license issued by the Nuclear Regulatory Commission or an agreement state.
micro-	A prefix meaning one-millionth, e.g., 1 microcurie = 1 x 10 curies.
milli-	A prefix meaning one-thousandth, e.g., 1 millicurie = 1 x 10 curies.
nuclide	Any species of atom that exists for a measurable length of time.
pocket dosimeter	A self reading, pencil size ionization chamber used for personnel monitoring purposes.
quality factor	A factor used to compare the biological effectiveness of absorbed radiation dose due to different types of ionizing radiation; equivalent to the term, RBE, relative biological effectiveness.
rad	The basic unit of absorbed dose of ionizing radiation; equals the absorption of 100 ergs of energy per gram of matter.
radiation	(a) The emission and propagation of energy through space or through a material in the form of waves.

	(b) The energy propagated through space or through materials as waves, usually referring to electromagnetic radiation. (c) By extension, particulates such as alpha or beta radiation or rays of mixed type.
radioactivity	The spontaneous decay or disintegration of an unstable atomic nucleus, accompanied by the emission of radiation.
radioassay	The process of analyzing biological material to determine its radioactive content.
radiography	The use of penetrating ionizing radiation to examine solid material.
radioisotope	An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation.
radiology	That branch of medicine which uses ionizing radiation for diagnosis
rem	Roentgen equivalent man. A unit of absorbed dose in biological matter, equals the absorbed dose in rads multiplied by the quality factor of the radiation.
roentgen	The amount of gamma or X-radiation required to produce ions carrying one electrostatic unit of charge in one cubic centimeter of dry air under standard temperature and pressure conditions.
sievert	The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1Sv = 100 rems).
source material	Any material, except special nuclear material, which contains 0.05 percent or more of uranium, thorium, or any combination of the two.
special nuclear	Plutonium, uranium-233, uranium containing more than the natural material abundance of uranium-235, or any material enriched by any of the substances.
survey	An evaluation of the radiation hazards incidental to the production, use or presence of radioactive materials or other sources of radiation under a specific set of conditions.
temporary job site	Any facility, utilized temporarily by a JSC-sponsored project, that is not under the administrative control of the JSC.
waste	Equipment and materials which are radioactive and, having no further (radioactive) use, are discarded.

X-radiation	Penetrating electromagnetic radiation of non-nuclear origin, usually produced by bombarding a metallic target with high speed electrons.

APPENDIX B - JSC Forms

1. Radioactive Material Use Authorization, JSC Form 1942
2. Radiation Machine Use Authorization, JSC Form 1943
3. Ionizing Radiation User Approval Request, JSC Form 1944
4. Radioactive Material Transfer Receipt, JSC Form 1625

Note: All forms are available on-line or contact the RSO.

APPENDIX C - References

(Available from Radiological Safety Office)

Code of Federal Regulations (CFR)

Title 10 - Energy

Title 29 - Occupational Health and Safety Administration, Part 1910.96 - Ionizing Radiation

Title 14 - U.S. Department of Transportation, Part 103 - Federal Aviation Administration

Title 39 - U.S. Postal Regulations, Parts 124-125 - Code of Federal Regulations

Title 49 - U.S. Department of Transportation, Parts 171-178 - Rules and Regulations

U.S. Postal Guide, Part I, Article 37, Chapter IV, Radioactive Materials

Rules and Regulations of States (Particularly in NRC Agreement States)

Provisions of Specific NRC and State Licenses

National Bureau of Standards Handbooks and National Committee on Radiation Protection Reports

National Council on Radiation Protection and Measurement Reports

Federal Radiation Council Reports

International Commission on Radiological Protection (ICRP) Reports

ADDITIONAL REFERENCES

Health Physics, Journal of the Health Physics Society (monthly)
Radiological Health Handbook, U.S. Public Health Service, PB 121 784 R
NRC Regulatory Guide 8.13, Standards for Protection Against Radiation

APPENDIX D - U.S. Nuclear Regulatory Commission Regulations and Guides

(Available from Radiological Safety Office)

1. Notices, Instructions and Reports to Workers; Inspections (10 CFR 19).

2. Standards for Protection Against Radiation (10 CFR 20).

3. Instruction Concerning Prenatal Radiation Exposure (Regulatory Guide 8.13).

APPENDIX E - Occupational Safety and Health Administration Standards

(Available from Radiological Safety Office)

APPENDIX F - NASA/JOHNSON SPACE CENTER
ALARA PROGRAM
JANUARY 1993

1. Management Commitment

   a. We, the management of this institution are committed to the program described herein for keeping individual and collective dose as low as is reasonable achievable (ALARA). Pursuant to this commitment, we hereby describe an administrative organization for radiation safety and shall develop the necessary written policy, procedures, and instruction to foster the ALARA concept within our institution. The organization shall include a Radiation Safety Committee and a RSO.

   b. We shall perform a formal annual review of the radiation safety program, including ALARA considerations. This shall include reviews of operating procedures and past dose records, inspections, etc., and consultations with the radiation safety staff or outside consultants.

   c. Modifications to operating and maintenance procedures and to equipment and facilities shall be made if they shall reduce exposures unless the cost, in our judgment, is considered to be unjustified. We shall be able to demonstrate, if necessary, that improvements have been sought, that modifications have been considered, and that they have been implemented when reasonable. If modifications have been recommended but not implemented, we shall be prepared to describe the reasons for not implementing them.

   d. In addition to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the dose received by all exposed individuals shall also be maintained at the lowest practicable level. It would not be desirable, for example, to hold the highest doses individuals to some fraction of the applicable limit if this involved exposing additional people and significantly increasing the sum of radiation doses received by all involved individuals.

2. a. Review of Proposed Users and Uses

      (1) The RSC shall thoroughly review the qualifications of each applicant with respect to the types and quantities of materials and methods of use for which application has been made to ensure that the applicant shall be able to take appropriate measures to maintain exposure ALARA.

      (2) When considering a new use of byproduct material, the RSC shall review the efforts of the applicant to maintain exposure ALARA.

      (3) The RSC shall ensure that the users justify their procedures and that individual and collective doses shall be ALARA.

   b. Delegation of Authority

      (The judicious delegation of Radiation Safety Committee authority is essential to the enforcement of an ALARA program).

(1) The Radiation Safety Committee shall delegate authority to the RSO for enforcement of the ALARA concept.

(2) The Radiation Safety Committee shall support the RSO when it is necessary for the RSO to assert authority. If the Radiation Safety Committee has overruled the RSO, it shall record the basis for its action in the minutes of the quarterly meeting.

c. Review of ALARA Program

(1) The RSC shall encourage all users to review current procedures and develop new procedures as appropriate to implement the ALARA concept.

(2) The RSC shall perform a quarterly review of occupational radiation exposure with particular attention to instances in which the investigational levels in Table 1 are exceeded. The principal purpose of this review is to assess trends in occupational exposure as an index of the ALARA program quality and to decide if action is warranted when investigational levels are exceeded (see Section 6 below for a discussion of investigational levels).

Table 1 – Investigational Levels

	Investigational Levels (mrems per calendar quarter)	
	Level I	Level II
1. Whole body, head and trunk, active blood-forming organs, lens of eyes, or gonads	125	375
2. Hands and forearms, feet and ankles	1875	5625
3. Skin of whole body	750	2250

(3) The Radiation Safety Committee shall evaluate our institution's overall efforts for maintaining exposures ALARA on an annual basis. This review shall include the efforts of the RSO, authorized users, and workers as well as those of management.

3. Radiation Safety Officer

a. Annual and Quarterly Review

(1) Annual review of the radiation safety program. The RSO shall perform an annual review of the radiation safety program for adherence to ALARA concepts. Reviews of specific methods of use may be conducted on a more frequent basis.

(2) Quarterly review of occupational exposures. The RSO shall review at least quarterly the external radiation exposures of authorized users and workers to determine that their exposures are ALARA in accordance with the provisions of Section 6 of this program and shall prepare a summary report for the RSC.

(3) Quarterly review of records of radiation level. The RSO shall review radiation levels in unrestricted and restricted areas to determine that they were at ALARA levels during the previous quarter and shall prepare a summary report for the RSC.

b. Education Responsibilities for ALARA Program

(1) The RSO shall schedule briefings and educational sessions to inform workers of ALARA program efforts.

(2) The RSO shall ensure that authorized users, workers, and ancillary personnel who may be exposed to radiation shall be instructed in the ALARA philosophy and informed that management, the RSC, and the RSO are committed to implementing the ALARA concept.

c. Cooperative Efforts for Development of ALARA Procedures

Radiation workers shall be given opportunities to participate in formulating the procedures that they shall be required to follow.

(1) The RSO shall be in close contact with all users and workers in order to develop ALARA procedures for working with radioactive materials.

(2) The RSO shall establish procedures for receiving and evaluating the suggestions of individual workers for improving radiation protection and will encourage the use of those procedures.

d. Reviewing Instances of Deviation from Good ALARA Practices

The RSO shall investigate all known instances of deviation from good ALARA practices and, if possible, shall determine the causes. When the cause is known, the RSO shall require changes in the program to maintain exposures ALARA.

4. Authorized Users

a. New Methods of Use Involving Potential Radiation Exposures

(1) The authorized user shall consult with, and receive the approval of the RSO and/or RSC during the planning stage before using radioactive materials for a new method of use.

(2) The authorized user shall evaluate all methods of use before using radioactive materials to ensure that exposures will be kept ALARA. This may be enhanced by using trial runs.

b. Authorized User's Responsibility to Supervised Individuals

(1) The authorized user shall explain the ALARA concept and the need to maintain exposures ALARA to all supervised individuals.

(2) The authorized user shall ensure that supervised individuals who are subject to occupational radiation exposure are trained and educated in good health physics practices and in maintaining exposures ALARA.

5. Individuals Who Receive Occupational Radiation Exposure

a. Workers shall be instructed in the ALARA concept and its relationship to work procedures and work conditions.

b. Workers shall know what recourses are available if they feel that ALARA is not being promoted on the job.

6. Establishment of Investigational Levels in Order to Monitor Individual Occupational External Radiation Exposures

This institution hereby establishes investigational levels for occupational external radiation doses which, if exceeded, shall initiate review or investigation by the Radiation Safety Committee and/or the RSO. The investigational levels that we have adopted are listed in Table 1. These levels apply to the exposure of individual workers.

The RSO shall review and record on Form NRC-5, "Current Occupational External Radiation Exposures", or an equivalent form (e.g., dosimeter processor's report) results of personnel monitoring not less than once in any calendar quarter as required by 20.2106 of 10 CFR Part 20. The following actions shall be taken at the investigational levels as stated in Table 1:

a. Personnel dose less than Investigational Level I.

Except when deemed appropriate by the RSO, no further action shall be taken in those cases where an individual's dose is less than Table 1 values for the Investigational Level I.

Personnel dose equal to or greater than Investigational Level I but less than Investigational Level II.

The RSO shall review the dose of each individual whose quarterly dose equals or exceeds Investigational Level I and shall report the results to the review at the first Radiation Safety Committee meeting following the quarter when the dose was recorded. If the dose does not equal or exceed Investigational Level II, no action related specifically to the exposure is required unless deemed appropriate by the Committee. The Committee shall, however, review each such dose in comparison with those of others performing similar tasks as an index of ALARA program quality and shall record the review in the Committee minutes.

b. Personnel dose equal to or greater than Investigational Level II.

The RSO shall investigate in a timely manner the causes of all personnel doses equaling or exceeding Investigational Level II and, if warranted, shall take action. A report of the investigation, and actions taken, and a copy of the individual’s Form NRC-5 or its equivalent shall be presented to the Radiation Safety Committee at its first meeting following completion of the investigation. The details of these reports shall be included in the Radiation Safety Committee minutes.

c. Reestablishment of Investigational Level II to a level above that listed in Table 1.

In cases where a worker's or a group of worker's doses need to exceed Investigational Level II, a new, higher Investigational Level II may be established on the basis that it is consistent with good ALARA practices for that individual or group. Justification for a new Investigational Level II shall be documented.

The Radiation Safety Committee shall review the justification for and shall approve all revisions of Investigational Level II. In such cases, when the exposure equals or exceeds the newly established Investigational Level II, those actions listed in paragraph 6.c above shall be followed.